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Impact of iron ore mining on air: A case study of Keonjhar district, Odisha

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Abstract
Opencast mining creates serious air pollution in the mining area. There is no well-defined method for assessing the impact on air quality due to mining activities. An investigation is conducted to assess the air quality status in the mining area, industrial area & rural residential area of Barbil, Keonjhar Odisha. Different sites have been selected to measure the standard of air quality of this region. The air quality was assessed by measuring Suspended Particulate Matter (SPM), PM_{10} (Respirable Suspended Particulate matter), Sulphur Dioxide (SO_2) & oxides of Nitrogen (NO_X). It is found that the average AQI Value is more in mining area than the Industrial & residential area.

Keywords: AQI, SPM, PM_{10}, SO_2, NO_X, Keonjhar, Odisha

1. Introduction
The environmental pollution is the unfavorable alteration of our surroundings, wholly or largely as a byproduct of man's action. All natural ecosystems are self-balanced & were not affected by man until the dawn of civilization. The environmental changes are induced by man which imbalance the present day ecosystem. Human beings are being responsible for deteriorating the quality & standard of the natural environments [8]. The degradation of the environment was caused mostly by the activities such as burning of fossil fuels, smelting of ores, ore exploration, mining activities & primitive methods of sewage disposal etc.
The crucial role is played by human beings in the name of industrialization and development. Mining activities create more pollution in nature compared to any other human activities. Air pollution of the environment is not a new phenomenon. Operations of mines in general have been found the adverse effect on environment [5].
Mining and related activities contributed significant growth in infrastructure & raising the living standards of the mankind, however they also brought the degeneration & degradation of natural resources, health problem, pollution & socio-economic instability. There are definite rules related to the mining sector, big or small, operating or new has to obtain environmental clearance from the Govt. of India [4]. Noise pollution, especially which is due to blasting, might be reduced by strict adherence to noise emission standard [9]. In India the national ambient air quality standard (NAAQS) was formulated in1994 to assess & compare the air pollution level for different areas [1].

2. Study Area
The mineral resources of Odisha form a very significant constituent of India's mineral wealth. The main resources are Chromite, Bauxite, Coal, Iron ore and Manganese ore. Mineral resources lead to increased exploitation and development of large size mines to meet the demand of a number of existing and proposed industries in Odisha. Near about 1200 sq. km. or more than that area of the State is under mining leases, which accounts more than 0.7% of the total geographical area of the state. Bonai – Keonjhar belt of Odisha is closely concentrated with manganese deposits. This belt is associated with Banded Iron Formation (BIF) of North Odisha. The major litho units of the area include BIF, Banded shales and mixed facies formation of the Iron Ore Group [6].
The study area, Barbil is a part of Keonjhar District. There are a number of mines clustered such as Bolani Mines, Gua mines, Kiriburu Mines, Tensa Mines etc. The study area is located between 22^0 05' 36" to 22^0 06' 06" N latitude and 85^0 21' 36" to 85^0 22' 6" E longitude. It lies at an average elevation of 477 m from the mean sea level (M.S.L.).

3. Materials and Methods
The method for sampling of particulate pollutant is based on the size of the particulate to be sampled. The selected sampling sites are Industrial, Residential, Mining cum residential & urban cum Vehicular area. Continuous monitoring of SPM, PM_{10}, SO_2, and NO_X was done every month for a period of one year during 2010-11. Ambient air quality was monitored using High volume sampler (Envirotech APM 460) 8hr daily for SPM, RSPM i.e. PM_{10} and gaseous pollutant. GF /A glass micro filter paper have been used for monitoring SPM. The SPM present in the air thus got deposits on the surface of filter paper. The filter paper was reweighed after sampling which gave the amount of SPM in the air during that time period. The RSPM samples were collected similarly through cyclonic flow technique. Similarly the SO_2 & NO_X have been monitored through High volume sampler attached with gas sampler. The SO_2 pollutant has been monitored through sodium tetra chloromercurate and analyzed by Spectrophotometer analysis. The absorbance fixed for this analysis is wavelength of 560 nm. Similarly NO_X has been monitored through sodium arsenate solution as absorbent and analyzed by using phosphoric acid. Hydrogen peroxide, sulphanilamide & NEDA (1-napthyl ethylene diaminedihydrochloride) through spectrophotometer. The absorbance fixed for this is 540 nm. It is to be noted that the weather conditions were suitable during sampling at most of the sites of the present investigation.

4. Results

The National Ambient Air Quality Standard (NAAQS) set by Central Pollution Control Board 1994 prescribed for residential, rural, industrial and sensitive areas are shown in Table 1.The nine sampling sites showing the value of AQI are indicated in Table 3.

Table 1: National Ambient Air Quality standard of central pollution Control Board (CPCB, 1994)

Pollutant	Time Weighted average	Concentration in Ambient Air			Method of measurement
		Industrial Area	Residential, Rural & other areas	Sensitive Area	
Sulphur Dioxide(SO_2)	Annual Average *	80 µg/m^3	60 µg/m^3	15 µg/m^3	Improved West & Gacke Method
	24 hours**	120 µg/m^3	80 µg/m^3	30 µg/m^3	Ultraviolet fluorescence
Oxides of Nitrogen as No_x	Annual Average *	80 µg/m^3	60 µg/m^3	15 µg/m^3	Jacob & Hochheiser modified (Na-Arsenite) method
	24 hours**	120 µg/m^3	80 µg/m^3	30 µg/m^3	Gas Phase Chemiluminescence
Suspended Particulate Matter (SPM)	Annual Average *	360 µg/m^3	140 µg/m^3	70 µg/m^3	(Average flow rate not less than 1.1 m^3/minute) Gravimetric Method
	24 hours**	500 µg/m^3	200 µg/m^3	100 µg/m^3	
Respirable Particulate matter (Size less than 10 µm)(RPM)	Annual Average *	120 µg/m^3	60 µg/m^3	50 µg/m^3	
	24 hours**	150 µg/m^3	100 µg/m^3	75 µg/m^3	

***** - Annual arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly
** - 24 hourly/8 hourly values should be met 98% of the time in a year. However, 2% of the time, it may exceed but not on two consecutive days. m exceed but not on two consecutive days.

4.1 Air Quality Index (AQI)

It is an environmental index which describes the overall ambient air status & trend of a particular place based on specific standard. It is a tool that transforms the calculated values of individual air pollutants in to a single number [3, 7, 10, 15, 12]. There are several methods to calculate the air quality index. For this study particular AQI method developed by Zlauddin *et al.*, 2006 was adopted to measure the concentration of pollutant to determine quality of ambient air.

$$AQI=1/4 \times (I_{SPM}/S_{SPM} + I_{RSPM}/S_{RSPM} + I_{SO2}/S_{SO2} + I_{NOX}/S_{NOX}) \times 100$$

I_{SPM}, I_{RSPM}, I_{SO2} & I_{NOX} =Individual values of Suspended particulate matter, Respirable particulate matter, sulphur dioxide & Oxides of nitrogen respectively.
S_{SPM}, S_{RSPM}, S_{SO2}, & S_{NOX} = Standards of ambient air quality as prescribed by the central pollution control board of India.

The higher the AQI value, greater is the level of air pollution and greater is the health risk [10]. The AQI scale is divided into five categories as depicted in Table 2. It describes the range of air quality and its associated potential health effect. The AQI of different locations are demonstrated in the Figure 1

Table 2: Rating scale of AQI (Index values of air quality index calculation)

AQI value	Remarks	Health concern
00-25	Clean air (CA)	Minimal/none health effect
26-50	Light Air Pollution(LAP)	Possible respiratory or cardiac effect for most sensitive group
51-75	Moderate Air Pollution(MAP)	Increasing symptoms of respiratory & cardiovascular diseases
76-100	Heavy Air Pollution(HAP)	Aggravation of heart & lungs diseases
>100	Severe Air Pollution(SAP)	Serious aggravation of heart & lung diseases. Risk of death in children

(* Source [11, 16])

Table 3: AQI of nine different locations of study area.

Sl. No	Name of the area	Type of area	Yearly AQI average	Remarks
1	Site 1	Industrial	85.381097	Heavy air pollution
2	Site 2	Industrial	95.941986	Heavy air pollution
3	Site 3	Industrial	96.629556	Heavy air pollution
4	Site 4	Industrial	79.952243	Heavy air pollution
5	Site 5	Residential	70.244271	Moderate air pollution
6	Site 6	Residential	89.518229	Heavy air pollution
7	Site 7	Residential	73.798073	Moderate air pollution
8	Site 8	Mining & Residential	143.00318	Severe air pollution
9	Site 9	Vehicular & residential	76.721625	Slightly heavy pollution

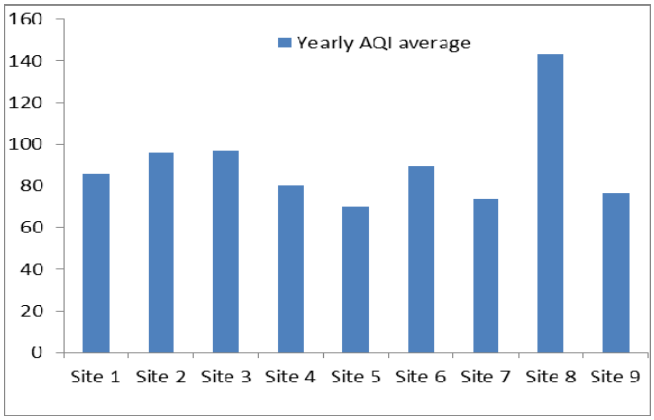

Fig 1: Yearly Air Quality Index avg. value of nine sites

The ambient air quality parameters (SPM, RPM, SO_2, NO_X) for the entire study period graphically represent station & month wise in the figure 2 to 5. The status of air quality in Indian environment is dominated by SPM [13], which is exactly reflected in the present experiment.

4.2. SPM

SPM-From the analytical study it was found that the concentration of SPM ranges from 110.02 to 901.01 µg/m^3. Site 6 have the lowest in July & site 2 is the highest in October. Average SPM value varies from residential to industrial area. SPM value is relatively high during October to February in all the nine sampling stations. The SPM value of site 1 exceeds the prescribed limit of SPM concentration according to National Ambient Air Quality Standard (NAAQS) set by Central Pollution Control Board 1994 during October to June but has lower concentration of SPM during July to September. Site 2 and 3 have more of concentration of SPM during September to June & below during July & August. Site 4 has more concentration of SPM during October to March and lower value during April to Sept. Site 8 and 9 are found to have more concentration of SPM during all months.

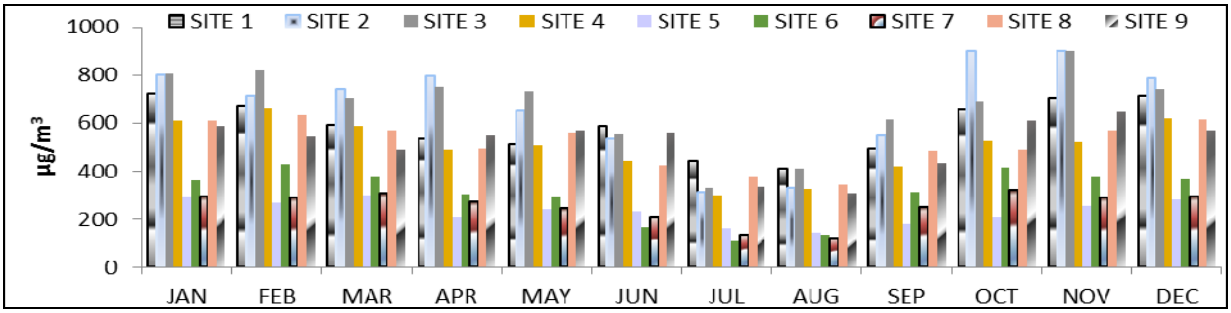

Fig 2: Month-wise variation in concentration of SPM

4.3. RSPM (PM_{10})

Like SPM trend, RSPM also ranges from 71.02 to 499.32 µg/m^3. Site 6 has the lowest in July & site 2 is the highest in October. Average PM_{10} value varies from residential to industrial area. Site 1, 2, 3, 4, 8, 9 have value exceeding the prescribed limit of PM_{10} concentration as per the National Ambient Air Quality Standard (NAAQS) set by Central Pollution Control Board (1998) during all twelve months. Site 5 shows below the conc. of PM_{10} during July to September and rest of the year shows higher concentration of PM_{10}.

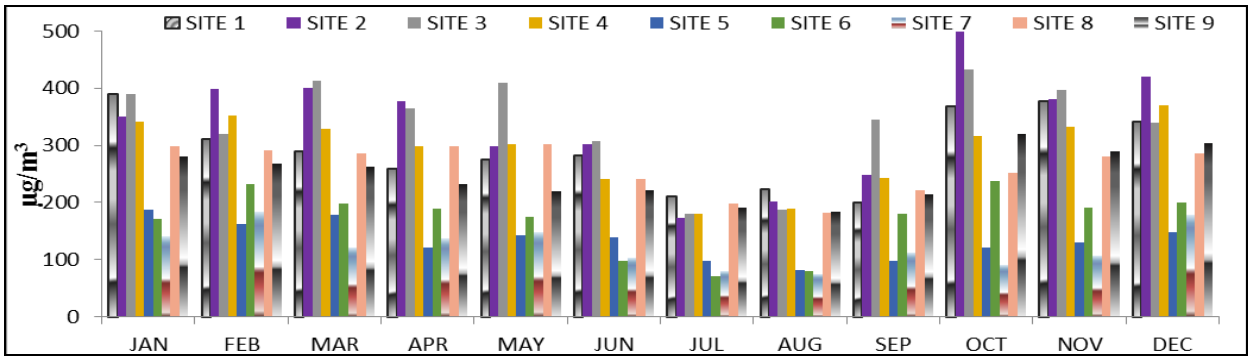

Fig 3: Month-wise variation in concentration of PM_{10}

4.4. SO_2

There is no significant result in the detection regarding SO_2. All the values are below the standard prescribed by CPCB. The highest value is found to be 16.65 µg/m^3 at site no 3 during January & lowest value found to be 2.3 µg/m^3 at site no. 5 during July.

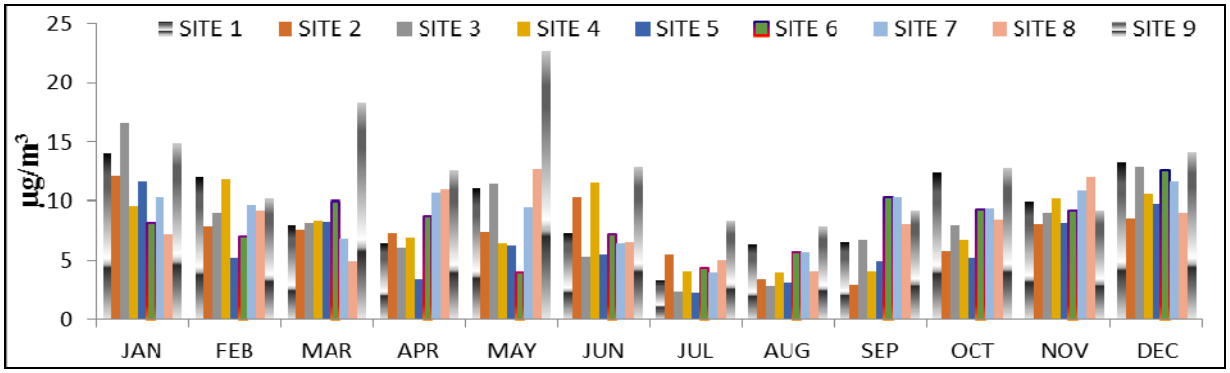

Fig 4: Month-wise variation in concentration of SO_2

4.5. NO_X- All the values are below the standard prescribed by CPCB. The highest value found to be 42.36 µg/m^3 at site no. 1 during December and lowest value found to be 5.99 µg/m^3 at site no. 4 during July.

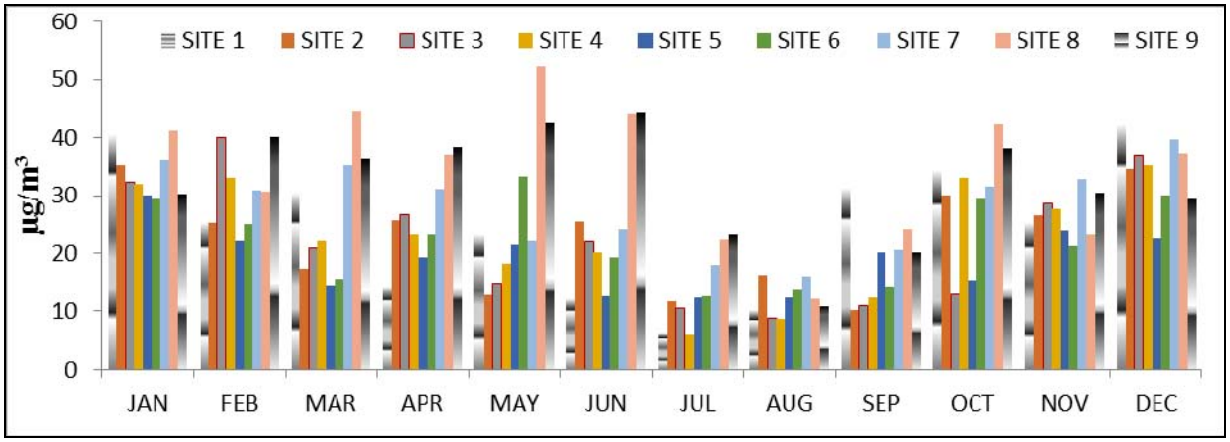

Fig 5: Month-wise variation in concentration of NO_X

5. Conclusion

Main problem of Air pollution in opencast mining is due to dust. It is found that the average AQI Value is more in mining area than the Industrial & residential area. Mining is such an activity which requires strict control at all the stages i.e. from exploration to consumption. Mining authorities using the measures to control pollution are inadequate and an urgent action is required to control the pollution. Work zone and ambient air quality also reveals the high pollution potential in the study area and surrounding locations. Air pollution control measures involve planning and implementation of a series of preventive and suppression measures in addition to dust extraction system. By proper implementation of abatement measures air pollution in opencast mining can be suitably managed.

6. Acknowledgements

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